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CAUSES OF THE NONCOALESCENCE OF WATER DROPLETS IN COLLISION

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In a study of the causes of the noncoalescence of droplets during long contact we [1, 2] showed that when two droplets are statically juxtaposed they may continue to coexist, even in a deformed state, for an unlimited period of time without coalescing. Moreover, it was established that the basic cause preventing the coalescence of the droplets was an excess pressure originating in the air-vapor gap between droplets due to the suction of the air by the vapor of the liquid, the vapor being diffused out from the gap.

To investigate the action of this force under dynamic conditions during the collision of droplets, we worked out a special method whereby we could bring about a collision between droplets of any liquid at any relative moisture content of the environment. We also studied the effect of a deficiency in moisture on the coalescence process of droplets.

To drive droplets into collision from capillary a (Figure 1) we squeezed out droplets with a radius of 0.4 mm. After falling from a height of 13 mm on a mirror C placed at an angle α with the horizon and covered by a fine film of liquid, the droplets rebounded from it and in their further motion collided with a droplet of the same size hanging on the platinum ring b. The distance between the mirror and the droplet hanging on the platinum ring can be regulated with the aid of a micrometric screw d to which a vernier e is attached.

To produce around the droplet an atmosphere with a fixed vapor content of the same liquid, the device was installed under a glass bell ground to the plate glass ψ. Saturation was brought about by blowing air in continuously and recirculating it by means of a closed system through coil H which was immersed in a heated bath and filled with liquid to 2/3 of its volume. Humidity was determined by an Assman psychrometer Q mounted in the apparatus, and also by a hair hygrometer K. The air was circulated in the closed system by means of an electric fan Z installed in the Assman psychrometer.

This set-up made it possible to obtain any given humidity above that of the atmosphere. If the working conditions required a humidity less than that of the atmosphere, the coil pipe with the liquid was removed and a moisture absorber attached to the circuit.

All experiments on the collision of droplets were conducted at atmospheric humidity or in an atmosphere saturated with moisture. At atmospheric humidity such conditions were established that all colliding droplets rebounded like elastic balls. Moreover, we fixed a distance between the direction of the vertical fall of the droplet and the droplet hanging on the platinum ring such that in its further very slight change towards a decrease in size (0.01 mm) during the collision, the droplet rebounding from the mirror coalesced with the droplet hanging on the platinum ring.

After fixing this "critical" distance, the process of completely saturating the atmosphere surrounding the droplets with vapor of the given liquid was carried out. When 100% relative humidity was reached, the droplets were again forced into a collision without changing the critical distance established previously. Thereby it was ascertained that in a saturated atmosphere all collisions led to coalescence of the droplets. It was found the critical distance in atmosphere saturated up to 98-100% is shifted towards an increase by 20-35% (see Table). An elastic rebound of colliding droplets was observed farther.

In interpreting the increase in the critical distance with the atmospheric saturation, it should be borne in mind that the character of the collision changes simultaneously with change in the critical distance, since the movement of the droplet is parabolic. Under our experimental conditions, with an increase of the distance H between the mirror and the motionless drop, its collision with the other droplet, rebounding from the mirror, will always be more oblique. It is easy to calculate that with an increase from H_1 to H_2 the collision must be lower by

$$\Delta = \frac{1}{4h} (H_2^2 - H_1^2).$$

Corresponding values of Δ are given in the Appended Table and equal to 0.1 - 0.2 mm, e.g. they are of the same order as the radius of the droplets (0.4 mm). Thus, we have before us a very important change in the character of the collisioh, giving evidence of the effect of a moisture deficit counteracting the coalescence of droplets in collision.

Hence, it follows from our work that the forces which are capable of preventing the coalescence of droplets under static conditions play a similar, though less decisive part in the collision of droplets.

In conclusion, we wish to express our gratitude to Professor B. V. Deryagin for his valuable suggestions in carrying out this work.

Bibliography

1. B. V. Deryagin, P. S. Prokhorov, DAN, 54, 511, 1946.
2. P. S. Prokhorov, Zh. Fiz. Khim. (At the printer's)

~~Editorial: Table follows; reproduce 1 figure from original.~~

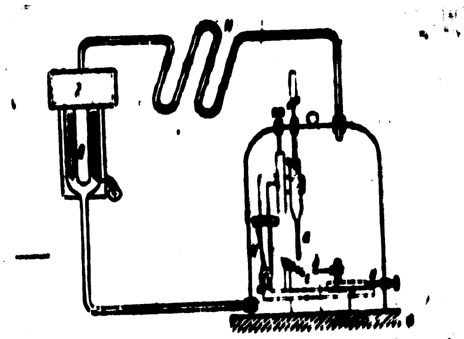

Figure 1. Diagram of apparatus

a - capillary
b - platinum ring
c - mirror
d - micrometric screw
e - vernier
H - coil
Q - Assman psychrometer
K - hair hygrometer
Z - electric fan

Table

Critical Distances for the Coalescence of Droplets on Collision

Name of Liquid	Distance drop falls h in mm	Relative Humidity in %	Angle of inclination of mirror α in degrees	Critical Distance in mm	Value Δ
Water	13	59	35	4.65	—
The same.	13	100	35	5.65	0.19
Aqueous solution of 2% magnesium sulfate.	13	59	35	3.7	—
The same.	13	100	35	4.7	0.16
Aqueous solution of 2% magnesium sulfate + + 3% sodium chloride.	13	59	35	2.7	—
The same	13	100	35	3.6	0.14

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